Cardiology in the Young

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The utility of a structured, interactive cardiac anatomy teaching session for resident education

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Abstract

Background: Paediatric residents are often taught cardiac anatomy with two-dimensional images of heart specimens, or via imaging such as echocardiography or computed tomography. This study aimed to determine if the use of a structured, interactive, teaching session using heart specimens with CHD would be effective in teaching the concepts of cardiac anatomy. *Methods:* The interest amongst paediatric residents of a cardiac anatomy session using heart specimens was assessed initially by circulating a survey. Next, four major cardiac lesions were identified to be of interest: atrial septal defect, ventricular septal defect, tetralogy of Fallot, and transposition. A list of key structures and anatomic concepts for these lesions was developed, and appropriate specimens demonstrating these features were identified by a cardiac morphologist. A structured, interactive, teaching session was then held with the paediatric residents using the cardiac specimens. The same 10-question assessment was administered at the beginning and end of the session. *Results:* The initial survey demonstrated that all the paediatric residents had an interest in a cardiac anatomy teaching session. A total of 24 participated in the 2-hour session. The median pre-test score was 45%, compared to a median post-test score of 90% ($p < 0.01$). All paediatric residents who completed a post-session survey indicated that the session was a good use of educational time and contributed to increasing their knowledge base. They expressed great interest in future sessions. *Conclusion:* A 2-hour hands-on cardiac anatomy teaching session using cardiac specimens can successfully highlight key anatomic concepts for paediatric residents.

The paediatric residency at the Oak Lawn campus of Advocate Children's Hospital resides within a children's hospital with a heart institute that performs between 400 and 500 paediatric cardiac surgical procedures each year. As such, paediatric residents have a great deal of exposure, and are involved in the care of many children with congenital malformations of the heart. Pertinent knowledge of cardiac anatomy varies among these paediatric residents. Education regarding cardiac anatomy can also be variable, and it is not infrequent that two-dimensional images or drawings are used to demonstrate complex three-dimensional cardiac malformations.[1] Traditionally, anatomy has been taught using preserved specimens, and these experiences are often primarily during medical school, with little specimen-based education during residency or fellowship. With respect to cardiac anatomy, surveys of paediatric cardiology fellows have demonstrated a perceived increase in understanding of cardiac anatomy and confidence after teaching sessions using heart specimens.[2-4] Little objective work has been done in assessing the efficacy of such cardiac anatomy teaching sessions amongst paediatric residents. Our study, therefore, aims to assess the efficacy of a structured, interactive, teaching session using heart specimens to demonstrate complex cardiac anatomy to paediatric residents.

Methods

Objective

As our institution cares for many children with congenital malformations of the heart, paediatric residents must care for a large number of children with such lesions. Understanding of either the anatomy or physiology generally requires knowledge and understanding of the other. Our current study aimed to assess the efficacy of a structured, interactive, teaching session using heart specimens to demonstrate complex paediatric cardiac anatomy.

Interest survey

A survey was distributed amongst the paediatric residents at our institution to assess their interest in a structured, interactive cardiac anatomy teaching session (supplemental Fig 1).

Identification of pertinent congenital cardiac malformations and cardiac anatomy

Congenital cardiac malformations of interest were identified by the authors by group consensus. The selection of lesions was influenced by the relative frequency of the lesions as encountered locally, to ensure that the paediatric residents would be taught the complex cardiac anatomy relevant to their clinical practice. The four lesions selected were atrial septal defect, ventricular septal defect, tetralogy of Fallot, and transposition of the great arteries. Based upon these lesions, a list of key anatomy was developed. This included identification of atrial morphology, assessment of the atrioventricular connections, identification of ventricular morphology, assessment of the ventriculoarterial connections, identifying the location of the atrioventricular node, and differentiation of the types of atrial and ventricular septal defects. These concepts were placed into a checklist for each congenital lesion deemed of interest.

Specimen selection

Specimens for the demonstration were selected from the Maurice Lev Congenital Heart & Conduction System Center by a trained cardiac morphologist. Specimens were selected based upon their adequacy in demonstrating the predefined cardiac anatomy. Specimens were washed prior to demonstration and all participants wore gloves.

Educational assessment

Once the aspects of anatomy had been identified, and appropriate specimens selected, a formal tool was developed to assess the knowledge regarding the anatomical structures and concepts. For ease of administration, this assessment was limited to 10 questions. The questions were reviewed and revised by multiple authors. The assessment is included as supplemental Fig 2.

Teaching session

A 2-hour teaching session was held during a block of time reserved for the education of the residents. The session instructors consisted of one attending paediatric cardiologist, and five paediatric cardiology fellows trained using similar specimens at this institution. The session began with the administration of the 10-question educational assessment, after which there was a 30-minute overview of sequential segmental anatomy as it pertains to the heart. After this, the paediatric residents were divided into four groups. Each group was then directed to a station where one of the paediatric cardiology fellows taught them about one of the selected congenital malformations of the heart. Each group spent 20 minutes at a single station, before rotating to the next station until all four stations were completed. At each station, paediatric cardiology fellows highlighted key aspects of cardiac anatomy that had previously been identified using one to two heart specimens. Approximately 10–15 minutes of teaching were provided by the paediatric cardiology fellow at each station. The remainder of the time was used to allow the paediatric residents to inspect the heart specimens and review the key anatomy of each lesion with the paediatric cardiology fellow. After the four stations were completed, the same 10-question educational assessment was re-administered. Within 1 week of the teaching session, a post-session survey was administered to assess the perceived utility of the session amongst the residents. This post-session survey is included as supplemental Fig 3. Due to the ongoing Covid-19 pandemic, the number of residents at each station was limited to 6, with appropriate measures of social distancing being used, including but not limited to use of protective facemasks.

Statistical Analyses

All frequencies are reported in absolute count and percentage, while all continuous data are presented as median and range. Scores of the educational assessment were compared from before and after the teaching session utilising a paired t-test. Three questions appeared on both the initial interest survey as well as the post-session survey. The responses to these were compared in a two-by-two fashion, with responses compared as those who responded "well" or "very well" versus those who responded "not well" on the initial interest survey and the post-session survey. A p-value of less than 0.05 was considered statistically significant. Any use of the word "significant" or "significance" throughout the manuscript refers to statistical significance unless explicitly stated otherwise. All statistical analyses were done using SPSS Version 23.0.

Results

The initial interest survey was completed by 33 paediatric residents. When asked "how well do you think you understand normal cardiac anatomy?" 30 (90.9%) responded "well" or "very well." When asked "how well do you think you understand the anatomy of simple cardiac lesions such as atrial septal defect and ventricular septal defect?" 29 (87.8%) responded "well" or "very well." When asked "how well do you think you understand the anatomy of complex cardiac lesions such as tetralogy of Fallot or transposition?" 14 (42.4%) responded "well" or "very well." All responders answered "yes" to whether or not they were interested in a 2-hour, interactive cardiac anatomy teaching session, and all answered "yes" to thinking that their understanding of cardiac anatomy would increase with such a teaching session. Responses to the interest survey are outlined in Tables 1 and 2.

A total of 24 paediatric residents attended the teaching session. The median proportion of correct responses on the educational assessment before the teaching session was 45% (range 10–90%) compared to 90% (range 30–100%) after the teaching session (p-value less than 0.01). This demonstrated a statistically significant increase in performance on the educational assessment in relation to the teaching session.

The post-session survey was limited to the 24 paediatric residents who attended the teaching session. Of these, 15 (62.5%) completed the post-session survey within a week. In response to "how well do you think you understand normal cardiac anatomy?", 12 (80.0%) responded "well" or "very well". In response to "how well do you think you understand simple cardiac lesions such as atrial septal defect or ventricular septal defect?", 15 (100%) responded "well" or "very well". In response to "how well do you think you understand complex cardiac lesions such as tetralogy of Fallot or transposition?", 11 (73.3%) responded "well" or "very well". All 15 (100%) responders responded "yes" when asked if they considered the teaching session had led to improvement in their knowledge of cardiac anatomy, if the teaching session was a good

Table 1. Pre-session survey confidence results

	How well do you think you understand normal cardiac anatomy?	How well do you think you understand the anatomy of simple cardiac lesions such as atrial septal defect and ventricular septal defect?	How well do you think you understand the anatomy of complex cardiac lesions such as tetralogy of Fallot, transposition, and common arterial trunk?
Not well	3 (9.1%)	4 (12.1%)	19 (57.6%)
Well or very well	30 (90.9%)	29 (87.9%)	14 (42.4%)

Table 2. Pre-session interest results

	Do you think your understanding of cardiac anatomy will improve with a two-hour “hands-on” session in which cardiac specimens with specific cardiac lesions are demonstrated?	Would you be interested in a two-hour “hands on” session in which cardiac specimens with specific cardiac lesions are demonstrated?
No	0 (0.0%)	0 (0.0%)
Yes	33 (100.0%)	33 (100.0%)

Table 3. Post-session survey confidence results

	How well do you think you understand normal cardiac anatomy?	How well do you think you understand the anatomy of simple cardiac lesions such as atrial septal defect and ventricular septal defect?	How well do you think you understand the anatomy of complex cardiac lesions such as tetralogy of Fallot, transposition, and common arterial trunk?
Not well	3 (20.0%)	0 (0.0%)	4 (26.7%)
Well or very well	12 (80.0%)	15 (100.0%)	11 (73.3%)

Table 4. Post-survey interest results

	Do you think your knowledge of normal and non-normal cardiac anatomy increased with the hands-on session?	Do you think the “hands-on” cardiac session was a good use of lecture time?	Would you be interested in having this “hands-on” cardiac lecture continue in the future?
No	0 (0.0%)	0 (0.0%)	0 (0.0%)
Yes	15 (100.0%)	15 (100.0%)	15 (100.0%)

use of their educational time, and if they would like such sessions in the future. Responses to the post-session survey are outlined in Tables 3 and 4.

A few questions from the initial interest survey were repeated in the post-session survey where responders who had taken both were compared. For how well responders considered they understood normal cardiac anatomy, there was no statistically significant difference (90.9% versus 80.0%, p-value 0.30). Concerning how well responders felt they understood simple cardiac lesions, there was no statistically significant difference (87.8–100%, $p = 0.29$). And, with respect to how well responders felt they understood complex cardiac lesions, there was a statistically significant difference (42.4–73.3%, $p = 0.02$).

Discussion

Our study demonstrates a few novel findings. Perhaps most importantly, paediatric residents are enthusiastic about learning about cardiac anatomy through an interactive teaching session using heart specimens. In our current study, all residents who responded to the post-session survey considered the session to have increased their knowledge, be a good use of their educational time and were interested in similar sessions in the future. The teaching sessions also demonstrated an increase in performance on an objective educational assessment, evidenced by a 100% increase in the median number of correct responses. Self-reported confidence in the understanding of complex lesions also increased significantly. While residents were assessed from all 3 years of residency, we did not feel that the knowledge level of these complex lesions differed greatly from PGY-1 to PGY-3.

Self-reported confidence in normal cardiac anatomy or simple congenital malformations of the heart, however, demonstrated no statistically significant difference. This is obviously in stark contrast to the objective improvement in knowledge as evidenced by the educational assessment. This highlights two things. First, having an objective and subjective measure of improvement is important in such educational endeavours. Second, teaching sessions can offer increased self-awareness regarding one’s own knowledge. Some who felt confident about their knowledge regarding cardiac anatomy seemed to have realised that their understanding of cardiac anatomy was perhaps not as good as they initially felt. This may have negatively impacted their self-reported confidence after the session, even though the objective assessment of their knowledge showed improvement.

Another unique component of our educational session was that the session relied heavily on the use of paediatric cardiology fellows as part of the teaching faculty. The cardiology fellows at our institution themselves participate in monthly cardiac morphology sessions based on the study of specimens from the Maurice Lev Congenital Heart & Conduction System Center. A different lesion is covered each month using the principles of sequential segmental analysis. The ability of the fellows successfully to teach the residents is a testament to their diligence during their own teaching sessions and by extension the efficacy of these teaching sessions. This conclusion, however, was not formally assessed.

Our findings are notable for several additional reasons. First, we have demonstrated that such teaching sessions utilising heart specimens increased knowledge of cardiac anatomy among paediatric residents. Second, such teaching sessions are deemed valuable by the residents. Third, the study highlights the importance of maintaining and preserving cardiac archives due to their value in teaching. Fourth, it highlights that paediatric cardiology fellows can successfully teach cardiac anatomy to paediatric residents.

While these findings are novel in the realm of education regarding cardiac anatomy as it pertains to congenital malformations of the heart, they are not entirely novel across all disciplines of anatomy. Medical students and residents historically taught with these two-dimensional images may lack the comprehension and retention that a three-dimensional experience may provide. A systematic review of studies comparing three-dimensional teaching tools to two-dimensional learning tools demonstrated that the three-dimensional options were objectively associated with improvement of correct identification of anatomic structures and improved understanding of spatial orientation. Three-dimensional teaching tools were subjectively associated with improvement in ease and enjoyment of learning.[5-8] The three-dimensional learning tools that have been previously evaluated for anatomical teaching include printed models, cadaveric specimens, and digital reconstructions. While these have all shown benefit over two-dimensional teaching tools, differences in efficacy between these models have not been as apparent. The neural response to three-dimensional, as opposed to two-dimensional teaching tools, demonstrates improvement in electroencephalography evidence of proper anatomic structure identification, retention, and transfer.[9] This seems to be underpinned by N250 event-related potentials and reward positivity. The N250 event-related potential increases with improved visual perception. Thus, the use of three-dimensional models as teaching tools is positively associated with improved visual perception[10-12].

It is not unprecedented that paediatric subspecialty fellows successfully teach paediatric residents. In fact, this is a time-honoured tradition across the disciplines of medicine and is even a formal milestone for some fellowship programmes.[13-15] One of the subjective strengths of this teaching session was that the paediatric cardiology fellows were allowed to teach, helping to solidify their grasp of the topic of interest as well as their teaching skills.[16] Additionally, many subspecialty fellows seek out such opportunities to teach, as was the case with the fellows involved with the teaching session outlined in a study conducted by McSparron et al.[17] Thus, such a teaching session provided not only an opportunity for paediatric residents to learn but also for the paediatric cardiology fellows further to develop and perfect their teaching skills.

While the teaching session that was the focus of our study has many strengths, it has its limitations. First, it is a single-centre experience, and the generalisability of the findings is questionable. Second, all centres may not have the heart specimens to match our experience. For centres without a robust collection of heart specimens, three-dimensional imaging in the form of CT or magnetic resonance imaging is a possible alternative for similar sessions.[18] Virtual reality or three-dimensional printed models, are also viable alternatives.[1,19,20,21] Finally, the findings of the statistical comparisons may be limited by the small sample size. Despite these potential shortcomings, such a teaching session has unequivocally been shown to be beneficial and is cost-efficient.

Supplementary material. To view supplementary material for this article, please visit https://doi.org/10.1017/S1047951122000440

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